Environment and Industry in Developing Countries

Assessing the Adoption of Environmentally Sound Technology

Ralph A. Luken and **Frank Van Rompaey**

With a foreword by **Mr Kandeh K. Yumkella, Director-General, UNIDO**

in association with
UNITED NATIONS INDUSTRIAL DEVELOPMENT ORGANIZATION

Published by
Edward Elgar Publishing Limited
Glensanda House
Montpellier Parade
Cheltenham
Glos GL50 1UA
UK

Edward Elgar Publishing, Inc.
William Pratt House
9 Dewey Court
Northampton
Massachusetts 01060
USA

A catalogue record for this book
is available from the British Library

Library of Congress Cataloguing in Publication Data
Luken, Ralph Andrew.
Environment and industry in developing countries : assessing the adoption of environmentally sound technology / by Ralph A. Luken, Frank Van Rompaey.
p. cm.
Includes bibiographical references and index.
1. Industrial management—Environmental aspects—Developing countries. 2. Technology—Environmental aspects—Developing countries. 3. Environmental management—Developing countries. I. Van Rompaey, Frank, 1964– II. Title.

HD30.255.L85 2007
338.9′27091724—dc22

2006034042

ISBN 978 1 84542 183 0

Printed and bound in Great Britain by MPG Books Ltd, Bodmin, Cornwall

Contents

Abbreviations

GENERAL

BAT	best available technology
BOD	biochemical oxygen demand
CETP	common effluent treatment plant
CIP	competitive industrial performance
COD	chemical oxygen demand
CP	cleaner production
CPI	consumer price index
CPT	cleaner production technology
CT	cleaner technology
CTs	clean techniques and technologies
EG	environmental governance
EIA	environmental impact assessment
EMS	environmental management system
EOP	end of pipe
EST	environmentally sound technology
ETP	effluent treatment plant
EU	European Union
EUI	energy-use intensity
FAO	Food and Agriculture Organization
FDI	foreign direct investment
FTZ	free trade zone
GDP	gross domestic product
GNI	gross national income
GNP	gross national product
IEA	International Energy Agency
IMF	International Monetary Fund
ISIC	international standard industrial classification
ISO	International Organization for Standardization
MFN	most favoured nation
MVA	manufacturing value added
NGOs	non-governmental organizations
ODA	overseas development assistance
PATs	pollutant abatement technologies

PPP	purchasing power parity
R&D	research and development
S&T	science and technology
SMEs	small and medium enterprises
SOE	state owned enterprises
TC	technological capabilities
TI	technology import
TMP	tariff on manufactured products
TOE	tons of oil equivalent
TRI	trade restrictiveness index
UNDP	United Nations Development Programme
UNEP	United Nations Environment Programme
UNIDO	United Nations Industrial Development Organization
WTO	World Trade Organization

SPECIFIC

Brazil

BRACELPA	Brazilian Association of Pulp and Paper Manufacturers
CNTL	Centro Nacional de Tecnologias Limpas Brazil
CONAMA	National Council of the Environment
IBAMA	The Brazilian Environmental Institute
MMA	Ministry of Environment

China

CNCPC	China National Cleaner Production Centre
EPB	Environmental Protection Bureau
SEPA	State Environmental Protection Agency
TVE	town and village enterprise

India

CPCB	Central Pollution Control Board
CTS	Centre for Technology Studies
MOEF	Ministry of Environment and Forests
NCPC	National Cleaner Production Centre
SPCB	State Pollution Control Board
SSI	small scale industry

Kenya

EPC	export Promotion Council
EPZ	export processing zone
EPZA	Export Processing Zones Authority
KES	Kenyan shillings
KIRDI	Kenyan Industrial Research and Development Institute
KNCPC	Kenya National Cleaner Production Centre
NEMA	National Environment Management Authority

Thailand

ASEAN	Association of South East Asian Nations
DANCED	Danish Cooperation for Environment and Development
DIW	Department of Industrial Works
IEAT	Industrial Estate Authority of Thailand
MOI	Ministry of Industry
MOSTE	Ministry of Science, Technology and Environment
PCD	Pollution Control Department
TEI	Thailand Environmental Institute
THTI	Thailand Textile Institute

Tunisia

ANPE	National Environmental Protection Agency
API	Industry Promotion Agency
CETTEX	Technical Centre for Textiles
CITET	Tunis International Centre for Environmental Technology
ETE	Euro-Tunisie-Entreprise Programme
MEAT	Ministry of the Environment and Land Use Planning
ONAS	National Sewerage Company
PMN	Industrial Upgrading Programme
SONEDE	National Water Supply and Exploitation Society

Viet Nam

ASEAN	Association of South East Asian Nations
MONRE	Ministry of Natural Resources and Environment
VEPA	Viet Nam Environment Protection Agency
VNCPC	Viet Nam National Cleaner Production Centre
VND	Vietnamese Dong

Zimbabwe

ESAP	Economic Structural Adjustment Programme
MET	Ministry of Environment and Tourism
SIRDC	Scientific and Industrial Research and Development Centre
ZNCPC	Zimbabwe National Cleaner Production Centre

Foreword by the Director-General of UNIDO

Technological change is key to achieving sustainable development. It is the essential basis for economic growth – the *sine qua non* for poverty reduction – and for the preservation of environmental quality.

UNIDO fully appreciates the importance of firm-level technological change for initiating a path of sustainable development. It works actively with the relevant national and international stakeholders to foster productivity growth in developing countries and in economies in transition. Growth in productivity results from producing goods more efficiently, producing goods of better quality and producing new goods. All these involve innovation and technological change.

In broad terms, technological change can be defined as any change in the way in which inputs are transformed into outputs. Undertaking such a change requires information, knowledge and skills on the part of the firm as well as a conducive business environment. Understanding this change process and its determinants is obviously crucial for stimulating the growth of higher-value production in developing countries. Moreover, an improved understanding of this process is instrumental in defining how public policy can shape technological change in more environmentally benign directions. While recent studies of technological change in developing countries have greatly advanced our insight into this process, more theoretical and empirical work is still needed – particularly in terms of its environmental aspects.

It is for this reason that UNIDO has undertaken this research to determine the factors that govern, in various circumstances, the adoption of environmentally sound technology (EST), which includes a variety of cleaner technology measures and pollution control solutions. This research aims to contribute to the debate on this subject and to further the understanding of how environmentally sound technological change can best be encouraged in developing countries. It underscores once more UNIDO's commitment to sustainable industrial development and builds upon the insights gained from its years of technical cooperation in technology transfer and the promotion of cleaner production. The results of this research will feed into the Organization's policy advisory services and technical cooperation interventions.

1. Introduction

INDUSTRY AND THE ENVIRONMENT

Developing countries, in spite of common perceptions to the contrary, have achieved major improvements in the environmental performance of their industry since the Rio Conference of 1992. They have performed better than developed countries in reducing energy-use and water-pollutant intensities between 1990 and about 2002; they cut the energy intensity of their production by 27 per cent, compared to only 8 per cent by developed countries, and the water-pollutant intensity by 49 per cent, compared to only 29 per cent by developed countries (see Chapter 2). These globally aggregated achievements are confirmed by developing-country case studies that show that numerous manufacturing plants in many developing countries, such as Bangladesh, China, Indonesia and Mexico, are in compliance with environmental norms (World Bank, 2000).

The improved environmental performance is not surprising for several reasons. First, environmentally sound technology (EST), particularly pollutant abatement technologies (PATs), are now readily available and well known, given their long development history – 50 years for air pollution and 150 years for water pollution (Anderson, 2001). Second, the costs of these technologies are low for many manufacturing sub-sectors compared to overall production costs. The costs of pollution control are on average about 2 per cent of production costs and around 15 per cent of one-time investment costs (OECD, 1993). Third, there is an increased understanding on the part of industry in developing countries of the importance of using cleaner technologies (CTs) in combination with PATs to achieve environmental compliance. Environmentally, CTs do not lead to the transfer of pollutants from one environmental medium to another, whereas PATs often do, as in the case of water pollution where PATs create secondary air-pollution and solid-waste problems; economically, CTs are generally productivity-enhancing and cost-lowering technological options, whereas PATs are only an added cost of production.

But in spite of this remarkable progress, there is still a large gap between the current environmental performance of industry in developing and developed countries. The energy-use intensity of industry remains almost three times higher in developing than in developed countries, water-use

intensity more than 11 times higher, water-pollutant intensity six times higher and carbon dioxide intensity four times higher (see Chapter 2). And with the accelerating industrialization of developing countries this gap could grow, if not necessarily in the intensity of energy use and pollutant release, certainly in the absolute amount of energy that will be used and the levels of pollution reached. The developing countries' share of global manufacturing value added (MVA) has already grown significantly, from 16.9 per cent to 25.5 per cent between 1990 and 2005, while the developed countries' share decreased from 78.6 to 70.3 per cent during the same period (UNIDO, 2005). Clearly it is essential that developing countries gain a better understanding of the factors motivating improved industrial environmental behaviour and of what they can do to strengthen these factors.

In light of the major environmental achievements that have been made in industry in developing countries and given, at the same time, the urgent need to take this further, it is surprising how little is actually known about the factors that have motivated industry in developing countries to comply with environmental standards and, more particularly, to adopt EST. Admittedly some investigations have been undertaken into these factors, most of them conducted directly by the World Bank or externally funded by the Bank. However, as seen in the literature review in Chapter 3, only a few studies have examined, directly or indirectly, the factors that have influenced plant-level decisions on the adoption of EST under the specific conditions faced in developing countries. Most of the recent studies on plant-level behaviour in developing countries have focused on factors determining environmental performance rather than technology choice because of the concern for reducing environmental pressure. Moreover these studies investigated only one or two countries, one or two sub-sectors and a limited set of factors affecting plant-level behaviour, making it difficult to generalize about what has accelerated the adoption of EST in developing countries.

The United Nations Industrial Development Organization (UNIDO), as the specialized United Nations agency promoting industrial development in developing and transitional economics, is keenly aware of the need to enhance the capacity of developing-country institutions to assist their industry in improving its environmental performance. UNIDO is actively supporting implementation of Agenda 21, approved by the United Nations Conference on Environment and Development (1992), and the Johannesburg Plan of Implementation, approved by the World Summit on Sustainable Development (2002). Both action plans implicitly recognize the need to close the gap in resource use and pollutant intensities between developed and developing countries and call for

urgent action to be taken to promote, facilitate and, as appropriate, finance the development, transfer and diffusion of EST and the corresponding know-how to and among developing countries (United Nations, 1992 and 2002). In supporting these two action plans, UNIDO recognized that successful technical assistance programmes to accelerate the adoption of EST in developing countries must be based on a sound empirical understanding of the multitude and relative importance of factors that influence EST adoption in these countries. To improve its understanding as well as that of the larger community of bilateral and multilateral organizations undertaking technical cooperation programmes in developing countries, UNIDO undertook a study in late 2001–early 2002 on the determinants of EST adoption by 98 plants in three manufacturing sub-sectors located in eight developing countries. The findings of this study are reported in this book.

This study was designed to identify the factors that determine the adoption of CTs as well as PATs. The aim was to document and assess the relative importance of factors that were broadly classified as contextual, that is, part of the plant's external environment, and those classified as plant-specific. Examples of contextual factors are buyer and environmental regulatory pressures; examples of plant-specific factors are environmental commitment and technological capabilities.

DEFINITION OF ENVIRONMENTALLY SOUND TECHNOLOGY (EST)

EST is often divided into two categories, abatement and prevention technologies. Abatement technologies, conventionally referred to as PATs, reduce the discharge of pollutants at the end of the production process. PATs collect pollutants, separating or neutralizing them in various ways (usually with specially built treatment installations). In contrast, prevention technology, often referred to as CTs, minimizes the generation of pollutants (and the utilization of some inputs such as water or fuel) throughout the production process. CTs are hence defined as manufacturing processes or product technologies that reduce both pollutant generation and the use of production inputs (raw materials, water and energy) in comparison to the technologies they replace. Although reducing the need for more costly abatement technologies, they require modifications in production processes, sometimes disrupting ongoing production activities.

OVERVIEW OF CHAPTERS 2 TO 13

Chapter 2

The differences in trends in the decoupling of environmental pressure from industrial growth in developed and developing countries, which is the underlying reason for undertaking this study, are compared in this chapter. First, the Organization for Economic Cooperation and Development (OECD) approach to estimating decoupling of economic growth from environmental pressure is described. Then global trends in decoupling for energy use, water use, organic matter effluent and carbon dioxide emission (CO_2) are compared between 1990 and 2002. A brief description of the three factors that have influenced these trends – scale, sub-sectoral composition and technological configuration – concludes the chapter.

In Appendix 2A in Chapter 2 selected evidence is provided on the potential of CTs to reduce industrial pollutants in the three sub-sectors covered in this study: textiles; pulp and paper; and leather processing. The annex consists of a generic description of CT options with examples of CT applications in country-specific situations.

Chapter 3

The heuristic model that guided this investigation of factors determining the adoption of EST in developing countries is presented in this chapter. First, the literature on technology diffusion and technological capabilities is briefly reviewed, followed by a more detailed review of empirical studies of EST adoption in developing countries. The heuristic model, derived from this literature, is then described. Finally, the three modes of investigation identified in the heuristic model and applied in the research are introduced: assessment of policy effectiveness in the eight countries in this study; plant managers' and key informants' perceptions of factors that influenced EST adoption (perceived factors); and a statistical analysis of underlying factors that the country survey teams observed as influencing EST adoption (observed factors).

Chapters 4 to 11

Chapters 4 to 12 present eight country case studies that provide the background information needed for the three modes of investigation. In each country a local team carried out a survey of the factors influencing the adoption of EST in a particular sub-sector during the late 1990s/early 2000s: pulp and paper in Brazil, China, India and Viet Nam; leather

processing in Kenya and Zimbabwe; and textiles in Thailand and Tunisia. Using semi-structured questionnaires provided by UNIDO, they interviewed plant managers and key informants, the latter including employees of environmental regulatory agencies, technology centres, NGOs, business associations and chemical and equipment suppliers. Each team also provided background data on the country and on the selected sub-sector.

Each chapter describes the national economic and environmental context in which plants made their EST adoption decisions; the country's environmental, economic and technology policies; production in the selected sub-sector and characteristics of the plants investigated; and key informants and international donors, all of whom influenced the adoption of EST.

The environmental, economic and technology policies reviewed in each chapter are those most related to the adoption of EST:

- The environmental policies reviewed are those aimed at reducing pollutant discharge from industry into the environment: industry-related environmental legislation, institutional arrangements and policy instruments, basically, those measures concerned with industrial environmental management. A global comparison is then presented of the effectiveness of each country's environmental management policy.
- The economic policies reviewed, in addition to macroeconomic performance, are those that most directly affect technological modernization – industrial, trade and resource pricing policies – and the associated institutional arrangements, since more modern technology is usually cleaner technology. A global comparison is given of the effectiveness of each set of policies.
- The technology policies reviewed are those that have the potential to increase the adoption of EST, particularly CTs, by directing the technological infrastructure to support plant-level adoption of more productive technologies and to train workers to operate these technologies. This includes technology policies and programmes and associated institutional arrangements aimed at increasing productivity in the manufacturing sector, with special reference to the subsector investigated in each country. A global comparison is presented of the effectiveness of each country's technological capability.

Chapter 12

The findings from the three different modes of investigation used to identify the factors that influenced EST adoption in the eight countries are presented in Chapter 12. The first mode of investigation examines the relationship

between the three policy regimes that created the incentive structure brought to bear on plant-level behaviour via government, markets and civil society and the actual levels of resource-use and pollutant intensities that might be attributed to these policies. The second describes the perceptions of 98 plant managers and 91 key informants about the relative importance of government, markets and civil society as external drivers for EST adoption. The third uses statistical techniques to analyse the factors observed by the survey teams as having influenced plant-level behaviour at the 98 plants in the eight countries.

Chapter 13

A summary of the findings in Chapters 2 to 12, policy implications derived from these findings, and proposals for government programmes that build on these implications are presented in Chapter 13. These programme proposals are examples of how governments can increase the ability of and incentives for the manufacturing sector to adopt EST, by using the potential for several policy regimes to influence plant managers' decisions.

REFERENCES

Anderson, D. (2001), 'Technical progress and pollution abatement: an economic view of selected technologies and practices', *Environment and Development Economics*, **6** (3), 275–81.

OECD (1993), *Environmental Policies and Industrial Competitiveness*, Paris: Organization for Economic Cooperation and Development (OECD).

UNIDO (2005), *International Yearbook of Industrial Statistics 2005*, Cheltenham, UK and Northampton, MA, US: Edward Elgar Publishing.

United Nations (1992), 'Agenda 21', United Nations, New York (available on: http://www.un.org/esa/sustdev/documents/agenda21).

United Nations (2002), 'Johannesburg plan of implementation', United Nations, New York (available on: http://www.un.org/esa/sustdev/documents/WSSD).

World Bank (2000), *Greening Industry: New Roles for Communities, Markets and Governments*, Oxford, UK: Oxford University Press.